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HEALTH & SAFETY LABORATORY

Offshore ignition probability arguments

Report Number

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CONTENTS

EXECUTIVE SUMMARY

OBJECTIVES

To review offshore hydrocarbon release statistics to derive ignition probabilities for use by the industry/HSE. This information can then be used in safety cases and to target areas where releases or ignitions are more prevalent.

MAIN FINDINGS

The main findings are as follows.

a. In line with expectations ignition probabilities are lower in more highly classified hazard zones: 3 % of Zone 1 releases ignited, 6 % of Zone 2, and 16 % in unclassified areas. Given the rigorous nature of controls, standards of equipment etc. in zoned areas, ignition probabilities in the region of 3 – 6 % for flammable releases would appear extremely high.
b. Analysis of ignitions by material, show non-process releases are both the most common cause of fire and have the highest ignition probability: approximately 1 in 3 releases ignite. Detailed examination of the HCR data shows 161 fires associated with escape of diesel and 58 due to lubricating oil.
c. Comparison of ignition probabilities for materials according to release size has shown minor releases may be more likely to ignite. For some materials, however, the number of releases are small, so the apparent decrease in ignition probability may be an artefact.
d. The absence of ignited major releases cannot be taken to mean that major releases will not ignite. In line with point (c), above, it simply means there have been insufficient major releases to generate a statistically valid release.

   Given that ignition probabilities are around 1 in 50 for many materials reviewed, and the number of reported major releases for the worst case is only just over 100, it is easy to see there have simply not been enough rolls of the dice for an ignition to occur.
e. The review of emergency actions shows:
   a. the larger the release to more likely it is that musters will be called or other emergency actions taken; and,
   b. musters or other emergency actions are more likely to be called following ignited releases.

   It has also been found that even with minor releases there have been a number of cases where personnel were mustered, not at stations, but at the lifeboats, demonstrating the perceived severity of the event. Given that the Pier Alpha disaster started with a minor release, such prudence cannot be criticised.
f. Study if figures relating to detection of releases with gas detection equipment has shown some 44 % of all gas releases, or 38 % of major gas releases remain undetected by the equipment fitted for that purpose. This would raise considerable doubts about the placement of such equipment.

RECOMMENDATIONS

Monitoring of the HCR database should continue to provide evidence of ongoing improvements in offshore safety, more reliable ignition probabilities, and detailed evidence on the causes of releases.

1 INTRODUCTION

In recent years there have been two instances of work on the potential severity of the consequences of ignition of gas releases in offshore incidents being contested in court. In one of these cases, a gas release on NW Hutton, the defence successfully challenged the assessment, and the potential precedence was set that, as an ignition source was not found during the investigation, the chance of ignition was very low.

In a second case, a gas release on the Brent Alpha platform, the potential for ignition was again contested, although not to the same degree. Even so, several arguments were put forward in an attempt to show that there was little potential for ignition of the release.

Thus, in view of recent events, it is proposed to investigate the validity of recent arguments to enable a firmer stand to be taken on the potential severity of unignited gas releases and the probability of ignition. This is to be achieved through review of information extracted from OIR/12s submitted by operators following releases.

The review of reported incidents is aimed at developing a better understanding of the circumstances in which ignition has occurred in past cases, and the identification of significant factors that may contribute to enhancing ignition potential. The main areas for consideration are as follows.

i. the number of reported "significant" and "major" releases
ii. nature of the release (oil, gas, quantity etc.)
iii. the number of ignited vs unignited releases
iv. whether definite ignition sources were found during investigations
v. hazardous area classification in the region of the incident

In the Brent Alpha case it was argued that the ignition probability for significant releases was only 1 in 48, and that for the 103 reported major releases the ignition probability would be lower as none had ignited.

Simple statistical examination of the number of reported incidents is required to:

a) counter invalid statistical arguments of this type;
b) show that a sample size of 103 unignited major releases is too small to place any certainty on non-occurrence; and,
c) demonstrate that if the ignition probability is 1 in 48 for accidental releases, then this could apply both to significant and major releases.

All arguments are to be prepared in as simple a method as possible as the intended audience, a court or jury, will be unfamiliar with complex technical/statistical arguments.

2 HYDROCARBON RELEASE STATISTICS FROM THE OIR/12 DATABASE

2.1 RELEASE SIZE DEFINITIONS

Before summarising details listed in the database it is necessary to define an important definition used to describe the severity/potential severity of a release: namely the release size.

Releases are divided into three categories: major; significant; and, minor.

A major gas release would entail escape of over 300 kg of gas, significant between 1 - 300 kg and minor less than 1 kg. A full description is given in Appendix A.

A description as to the consequences of ignition of these releases also is appropriate.

<u>Major releases</u>
Gas - capable of forming a jet fire over 10 m long for over 5 minutes, or an explosive cloud filling an entire module of 3000 m^3 volume.
Liquid – could form a pool fire over 10 m diameter burning for over 15 minutes.
<u>Significant releases</u>
Gas – Capable of jet fires of 5 to 10 m long lasting between 2 – 5 minutes, or explosive clouds between 10 – 3000 m^3 volume.
Liquid – Pool fires between 2 – 10m diameter lasting between 5 –1 5 minutes.

<u>Minor releases</u>
Gas – an unstable jet fire of less than 5 m long for less than 2 mins, or a flammable cloud of less than 10 m^3 volume which is probably insufficient to cause significant hazard if ignited.
Liquid – A pool fire smaller than 2 m diameter burning for less than 5 minutes.

With the exception of minor releases, which, according to the accepted definition of these releases, only really have the potential to cause serious injury to personnel, both significant and major releases have potential to cause fatalities and significant escalation of the incident. Even so, it must be appreciated that even minor releases could lead to a jet flame up to 5 m in length, or a 2 m diameter pool fire. These dimensions may be small given the size and construction of some offshore structures, but they are still serious fires. Such a flame is still capable of causing considerable damage and it must be born in mind that the Piper Alpha disaster started with a minor ignited release.

2.2 STATISTICS 1992 TO JULY 2004

Table 1, below, contains a summary of releases over the period 1992, (when compilation of release statistics commenced), to July 2004. Listed are: the number of releases per year; the number ignited; area classifications; whether ignition was delayed or immediate; and, whether personnel were mustered.

Table 1 Summary of release statistics by year

Year	*92/93*	*93/94*	*94/95*	*95/96*	*96/97*	*97/98*	*98/99*	*99/00*	*00/01*	*01/02*	*02/03*	*03/04*	*All Years*
No. of releases	81	271	325	212	226	218	234	234	270	241	230	272	2814
No. ignited	4	26	24	9	18	9	18	10	13	12	7	14	164
% ignited	4.9	9.6	7.4	4.2	8.0	4.1	7.7	4.3	4.8	5.0	3.0	5.1	5.8
Delayed ignition	1	4	1	2	10	3	4	2	1	6	2	8	44
Immediate ignition	3	22	23	7	8	6	14	8	12	6	5	6	120
Muster	0	6	7	5	7	2	4	4	4	6	4	7	56
Zone 1	0	1	1	0	3	3	6	0	3	2	1	0	20
Zone 2	4	25	23	9	15	6	12	7	9	3	4	6	123
Unclassified	0	0	0	0	0	0	0	3	1	7	2	8	21

For the differing hazard zones found offshore these figures translate to those given in Table 2.

Table 2 Approximate ignition probabilities by hazard zone

	Total releases	***No. ignited***	***%***	***Approximate probability****
Zone 1	627	20	3.2	1 in 31
Zone 2	2055	123	6.0	1 in 17
Unclassified	132	21	15.9	1 in 6

*Note: all probabilities are approximate and are rounded to the nearest whole number.

Ignition probabilities in Table 2 are entirely in line with what would be expected, with Zone 1 having the lowest probability and unclassified areas the highest. It is disturbing to see, however, that 1 in 6 releases in unclassified areas ignite, which will in a large part be due to non-process leaks. A full breakdown of non-process releases is given in Section 2.3.

The available data is further analysed in the following sections where it is categorised according factors such as the nature of the release, area classification, release size etc. Whilst this provides some useful data, caution must be exercised in over-reliance on the data as the number of instances with which a particular scenario occurs is often small. When dealing with low probability events large data sets are required to give statistically valid data. As such the following breakdown contains much information which should be relied upon as giving indicative event frequencies, rather than absolute.

2.3 MUSTER AND EMERGENCY ACTIONS

2.3.1 Emergency actions following ignited releases

It is also evident from Table 1 that in many cases personnel were mustered, both for ignited and unignited releases, demonstrating the OIM’s perception of the potential severity of a flammable release.

A more detailed examination of ignited releases shows that personnel were mustered, at either stations or lifeboats, in 56 of the 164 releases. Thus in approximately one third of all ignited releases the situation was deemed severe enough to muster personnel prior to taking further emergency actions, or even to assemble at the lifeboats and make preparations for abandonment.

A thorough analysis of emergency actions by release size is as follows.

Table 3 Release size and number of instances of emergency actions for ignited releases for all area classifications

Release size	***Number of releases***	***Number ignited***	***Number and emergency actions for ignited releases***
Major	160	0	No muster: 92: but other emergency actions taken in 44 cases
			Mustered at stations: 65
			Mustered at lifeboats: 3
			Other emergency action (possibly with muster): 61
Significant	1476	42	No muster: 28 but other emergency actions taken in 15 cases
			Mustered at stations: 14
			Other emergency action (possibly with muster): 22
Minor	1178	122	No muster: 80: but other emergency actions taken in 40 cases
			Mustered at stations: 39
			Mustered at lifeboats: 3
			Other emergency action (possibly with muster): 53

Utilising this data the probability that personnel are mustered following an ignited release is given in Table 4.

Table 4 Summary of number of instances of emergency actions following ignited releases

Release size	***Muster (%)***	***Other emergency action (%)***	***No muster or other emergency action (%)***
Major	N/A	N/A	N/A
Significant	33.3	52.8	31.0
Minor	34.4	32.7	32.8

A breakdown of these figures according to material released is given in Table 5.

Table 5 Release type and number of instances of emergency actions for ignited releases

Release size	*Material released*	*Number*	*Emergency action taken*	*Number of instances*
Major	No ignited major releases	-	-	-
Significant	Oil	4	No muster	2
			Other emergency action taken	0
			Muster at stations	2
	Gas	18*	No muster	5
			Other emergency action taken	9
			Muster at stations	2
	2-phase	0	N/A	
	Condensate	1	Other emergency action	1
	Non-process	19	No muster	3
			Other emergency action taken	6
			Muster at stations	10
Minor	Oil	7 *	No muster	0
			Other emergency action taken	3
			Muster at stations	2
			Muster at lifeboats	1
	Gas	28 *	No muster	6
			Other emergency action taken	12
			Muster at stations	5
			Muster at lifeboats	1
	2-phase	0	N/A	-
	Condensate	10 *	No muster	3
			Other emergency action taken	3
			Muster at stations	3
	Non-process	77 *	No muster	17
			Other emergency action taken	22
			Muster at stations	29
			Muster at lifeboats	1

* Note data missing from HCR database in "other emergency action column". Detailed breakdown of actions will not total to the total number of releases listed for each material.

It is significant to note that even for minor fires and releases, musters or some form of emergency action was taken in approximately 75% of cases, and there were 3 instances where the situation was deemed severe enough to muster personnel at the lifeboats.

Given the description of what even a minor ignited release could look like, this is hardly surprising, as gas flames could be up to 5 m long, or in the case of liquid releases there could be a burning liquid pool around 2 m diameter. This would be likely to form flames up to 4 m high.

2.3.2 Emergency actions following unignited releases

The number of instances of emergency actions being taken as a result of unignited releases are given in Table 6.

Table 6 Release type and number of instances of emergency actions for unignited releases – Part A: Major and Significant releases

Release size	*Material released*	*Number*	*Emergency action taken*	*Number of instances*
Major	Oil	7	No muster or emergency action	3
			Other emergency action	2
			Muster at stations	2
	Gas	114 *	No muster or emergency action	29
			Other emergency action	29
			Muster at stations	46
			Muster at lifeboats	3
	2-phase	31	No muster or emergency action	5
			Other emergency action	10
			Muster at stations	16
	Condensate	1	Other emergency action	1
	Non-process	7	No muster or emergency action	4
			Other emergency action	2
			Muster at stations	1
Significant	Oil	208 *	No muster or emergency action	58
			Other emergency action	76
			Muster at stations	34
			Muster at lifeboats	3
	Gas	914 *	No muster or emergency action	257
			Other emergency action	231
			Muster at stations	276
			Muster at lifeboats	20
	2-phase	157 *	No muster or emergency action	55
			Other emergency action	40
			Muster at stations	47
			Muster at lifeboats	2
	Condensate	56 *	No muster or emergency action	20
			Other emergency action	15
			At stations	16
	Non-process	99 *	No muster or emergency action	31
			Other emergency action	39
			Muster at stations	9
			Muster at lifeboats	2

* Note data missing from HCR database in “other emergency action column”. Detailed breakdown of actions will not total to the total number of releases listed for each material.

Table 6 Release type and number of instances of emergency actions for unignited releases – Part B: Minor releases

Release size	*Material released*	*Number*	*Emergency action taken*	*Number of instances*
Minor	Oil	300 *	No muster or emergency action	69
			Other emergency action	94
			Muster at stations	29
	Gas	452 *	No muster or emergency action	89
			Other emergency action	90
			Muster at stations	143
			Muster at lifeboats	9
	2-phase	38 *	No muster or emergency action	14
			Other emergency action	7
			Muster at stations	2
	Condensate	138 *	No muster or emergency action	27
			Other emergency action	46
			Muster at stations	27
			Muster at lifeboats	3
	Non-process	128 *	No muster or emergency action	46
			Other emergency action	29
			At Muster at stations	9

* Note data missing from HCR database in "other emergency action column". Detailed breakdown of actions will not total to the total number of releases listed for each material.

Again, as per ignited releases there are a number of instances of personnel being required to muster at lifeboats.

A summary of actions taken following releases is given in numerical form in Table 7 and visually in Figure 1. Unfortunately, there are a considerable number of blank entries in the database for no-muster cases, especially for minor releases.

Table 7 Summary of instances of emergency actions following unignited releases

Release size	*Muster (%)*	*Other emergency action (%)*	*No muster or other emergency action (%)*	*Data incomplete. No muster, but other emergency action column blank*
Major	42.5	27.5	25.6	4.4
Significant	28.5 (33.3)	27.9 (38.1)	29.4 (23.8)	14.2 (4.8)
Minor	21.0 (30.3)	27.1 (32.8)	23.2 (20.5)	30.6 (19.8)

Note: bracketed figures relate to actions following ignition.

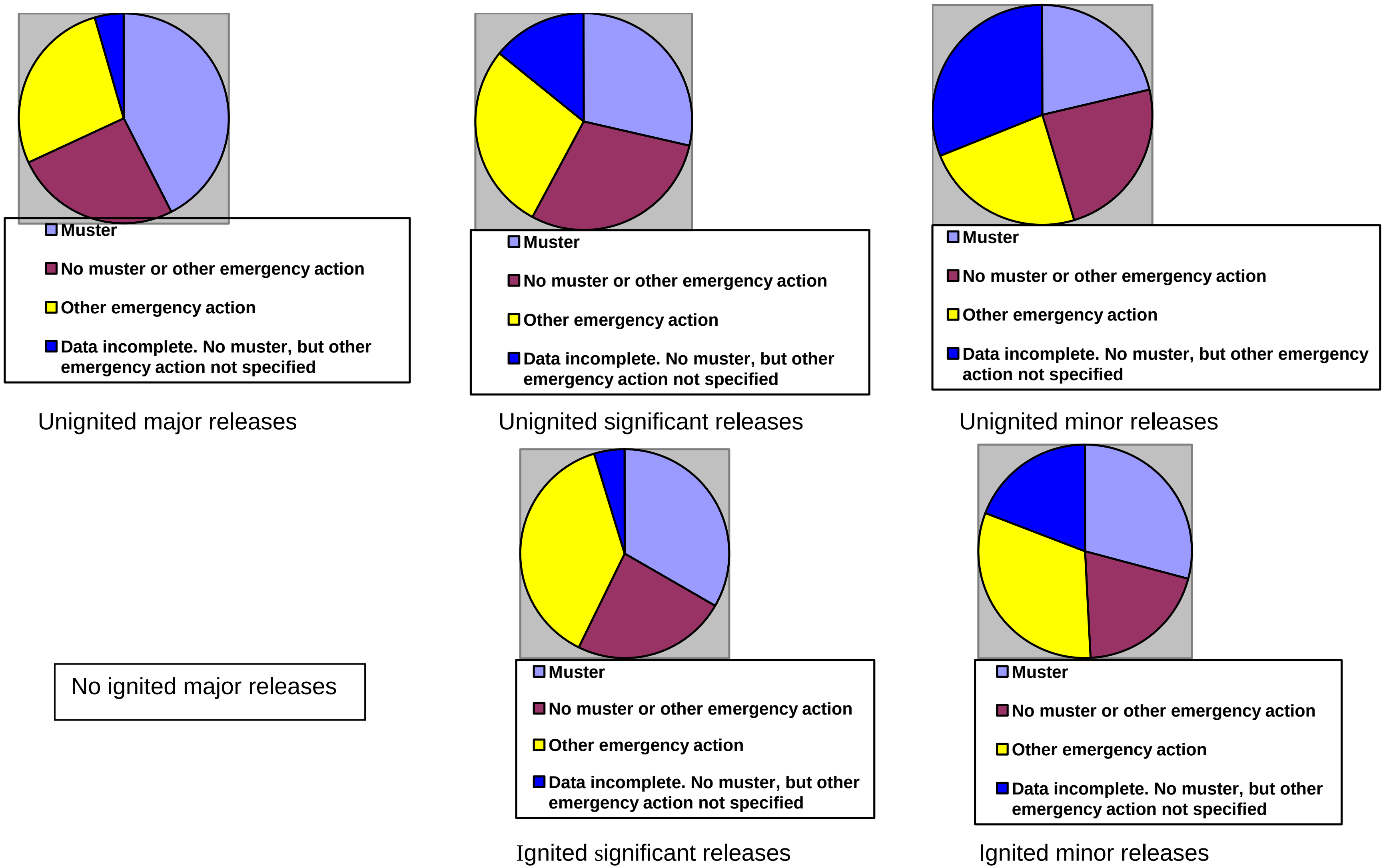

Figure 1 Summary of instances of emergency actions following reported hydrocarbon releases

From this it can be said that major releases are regarded as potentially very serious and in 42 % of cases personnel are mustered, with muster or some other form of emergency action, being taken following 70 % of releases.

For significant releases musters were called following 28 % of unignited releases compared to 33 % of ignited – broadly comparable figures. Whilst for emergency actions as a whole across significant releases the instances are 56 % when unignited releases, rising to 80 % for ignited releases. Again demonstrating the perceived severity of the event.

Probably as would be expected minor unignited releases have a lower incidence of muster, but even so, when ignited some form of emergency action is taken in 67 % of instances as there is still potential for escalation, as attested by the Piper Alpha disaster where it was thought the initial release of condensate was only at a rate of around 3 $kg.s^{-1}$.

2.4 ANALYSIS OF RELEASES ACCORDING TO HAZARDOUS AREA CLASSIFICATION

As well as reviewing materials, release size, etc., releases can also be listed according to their hazardous area classification (Table 8). Definitions of classifications used are as follows:

- Zone 1 – area in which an explosive atmosphere is likely to occur occasionally in normal operation;
- Zone 2 – area in which an explosive atmosphere is not likely to occur in normal operation, and if it does occur is likely to do so only infrequently and will exist for a short period only such as equipment failure, breakdown or service and maintenance;
- Non-hazardous or Unclassified areas – an area known not to contain any concentrations of flammable vapour, gas, liquid, or dust in the atmosphere.

Table 8 Events by release type and area classification for all release sizes

Area Classification	*Fluid type*	*Total releases*	*No. ignited*	*%*	*Approximate probability*
Zone 1	Oil	128	0	-	-
	Gas	355	9	2.5	1 in 39
	2-phase	60	0	-	-
	Condensate	48	2	4.2	1 in 24
	Non-process	36	9	25	1 in 4
Zone 1 total		**627**	**20**	**3.2**	**1 in 31**
Zone 2	Oil	385	11	2.9	1 in 35
	Gas	1130	35	3.1	1 in 32
	2-phase	160	0	-	-
	Condensate	157	8	5.1	1 in 20
	Non-process	223	69	30.9	1 in 3
Zone 2 total		**2055**	**123**	**6.0**	**1 in 17**
Unclassified	Oil	13	0	-	-
	Gas	41	2	4.9	1 in 21
	2-phase	6	0	-	-
	Condensate	1	1	100	1
	Non-process	71	18	25.3	1 in 4
Unclassified total		**132**	**21**	**15.9**	**1 in 6**
Total		**2814**	**164**	**5.8**	**1 in 17**

As discussed earlier in Section 2 the derivation of lower ignition probabilities for Zone 1 areas compared to unclassified areas is in line with expectations, as equipment must be manufactured and maintained in such a way that it is safe for use in potentially flammable atmospheres. What is not expected is the variation in ignition probabilities for individual materials.

Thus, taking Zone 1 as an example it can be seen that the ignition probability for a gas release is 2.5 %, whereas that for a non-process release is 10 times higher at 25 %. This very high ignition probability for non-process releases is carried across the board through all hazard zones and does not appear to be affected by increased safety levels of equipment in different areas. This trend is displayed graphically in Figure 2.

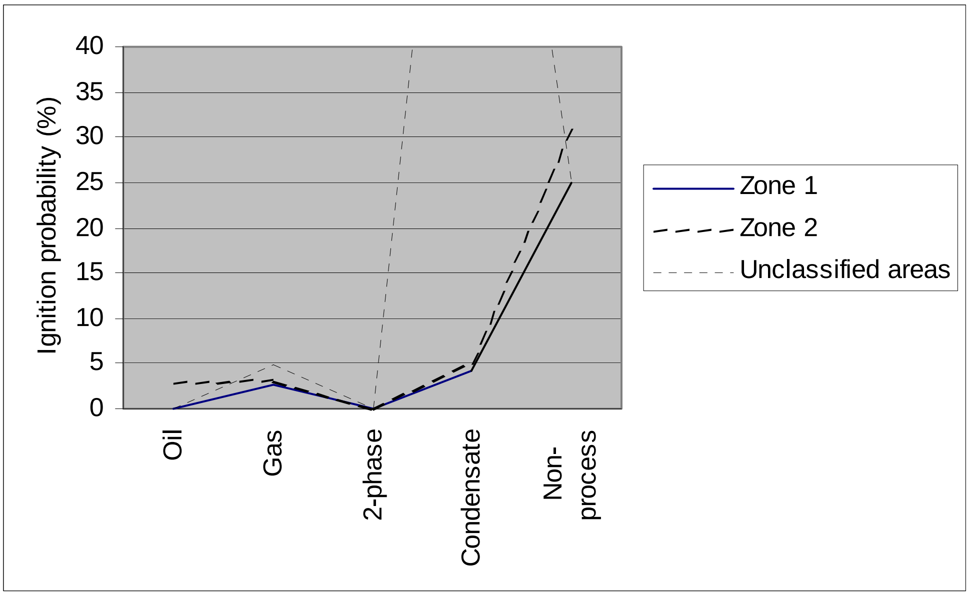

Figure 2 Ignition probabilities as a function of area classification

Note: the 100 % ignition probability for condensate in unclassified areas is anomalous as it relates to 1 ignition for 1 release.

Clearly as so many non-process releases ignite there is considerable scope for hazard reduction.

Further subdivision of the data listed in Table 8 according to material released and release size is also possible:

- Tables 9 & 10 show ignition probabilities by fluid released, area classification and size.

- Table 11, in the following section, gives a broader overview with less subdivision, and contains ignition probabilities by fluid released and size.

Table 9 Events by fluid released, area classification and size

Fluid type	*Area Classification*	*Release size*	*Number of releases*	*Number ignited*	*% ignited*	*Approximate probability*
Oil	Zone 1	Major	1	0	-	-
	Zone 1	Significant	49	0	-	-
	Zone 1	Minor	78	0	-	-
	Zone 2	Major	6	0	-	-
	Zone 2	Significant	159	4	2.5	1 in 40
	Zone 2	Minor	220	7	3.2	1 in31
	Unclassified	Major	0	0	-	-
	Unclassified	Significant	4	0	-	-
	Unclassified	Minor	9	0	-	-
Oil total			**526**	**11**	**2.1**	**1 in 48**
Gas	Zone 1	Major	22	0	-	-
	Zone 1	Significant	227	3	1.3	1 in 75
	Zone 1	Minor	106	6	5.7	1 in 18
	Zone 2	Major	88	0	-	-
	Zone 2	Significant	689	14	2.0	1 in 49
	Zone 2	Minor	353	21	5.9	1 in 17
	Unclassified	Major	4	0	-	-
	Unclassified	Significant	16	1	6.3	1 in 16
	Unclassified	Minor	21	1	4.8	1 in 21
Gas total			**1526**	**46**	**3.0**	**1 in 33**
Condensate	Zone 1	Major	0	0	-	-
	Zone 1	Significant	10	0	-	-
	Zone 1	Minor	38	2	5.3	1 in 19
	Zone 2	Major	1	0	-	-
	Zone 2	Significant	46	0	-	-
	Zone 2	Minor	110	8	7.3	1 in 14
	Unclassified	Major	0	0	-	-
	Unclassified	Significant	1	1	100	1
	Unclassified	Minor	0	0	-	-
Condensate total			**206**	**11**	**5.3**	**1 in 19**
2-Phase	Zone 1	Major	8	0	-	-
	Zone 1	Significant	41	0	-	-
	Zone 1	Minor	11	0	-	-
	Zone 2	Major	21	0	-	-
	Zone 2	Significant	112	0	-	-
	Zone 2	Minor	27	0	-	-
	Unclassified	Major	2	0	-	-
	Unclassified	Significant	4	0	-	-
	Unclassified	Minor	0	0	-	-
2-phase total			**226**	**0**	**-**	**-**
Non-process	Zone 1	Major	1	0	-	-
	Zone 1	Significant	14	1	7.1	1 in 14
	Zone 1	Minor	21	8	38.1	1 in 3
	Zone 2	Major	6	0	-	-
	Zone 2	Significant	86	16	18.6	1 in 5
	Zone 2	Minor	131	53	40.5	1 in 2
	Unclassified	Major	0	0	-	-
	Unclassified	Significant	18	2	11.1	1 in 9
	Unclassified	Minor	53	16	30.2	1 in 3
Non-process total			**330**	**96**	**29.1**	**1 in 3**

As stated earlier a large number of ignitions have been reported in unclassified areas. It may be reasonable to expect some non-process releases in these areas. But 41 gas releases have also occurred: 4 of which were categorised as major, and 16 significant. Given that such large gas releases have occurred it would suggest that some areas may be incorrectly classified.

2.5 IGNITION PROBABILITIES BY MATERIAL RELEASED

A breakdown ignition probabilities of materials for the three release size categories is presented in numerically in Table 10 and visually in Figure 3.

Table 10 Ignition probabilities by fluid released and release size

Fluid type	*Release size*	*Number of releases*	*Number ignited*	*% ignited*	*Approximate probability*
Oil	Major	7	0	-	-
	Significant	212	4	1.9	1 in 53
	Minor	307	7	2.3	1 in 44
Oil total		**526**	**11**	**2.1**	**1 in 48**
Gas	Major	114	0	-	-
	Significant	932	18	1.9	1 in 52
	Minor	480	28	5.8	1 in 17
Gas total		**1526**	**46**	**3.0**	**1 in 33**
Condensate	Major	1	0	-	-
	Significant	57	2	3.5	1 in 29
	Minor	148	10	6.8	1 in 15
Condensate total		**206**	**12**	**5.8**	**1 in 17**
2-Phase	Major	31	0	-	-
	Significant	157	0	-	-
	Minor	38	0	-	-
2-phase total		**226**	**0**	**-**	**-**
Non-process	Major	7	0	-	-
	Significant	118	19	16.0	1 in 6
	Minor	205	77	37.6	1 in 3
Non-process total		**330**	**96**	**29.1**	**1 in 3**

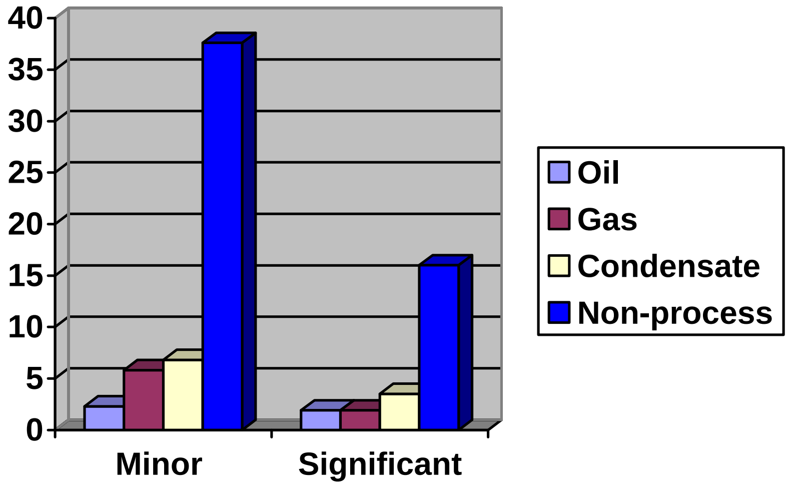

Figure 3 Percentage ignition probabilities for releases

This data would suggest smaller releases have a greater chance of ignition. However, it is possible that this apparent difference may simply be due to there being insufficient data to generate reliable figures for infrequent events.

For instance, the chance of ignition derived for oil releases differs by only 0.4 % between minor and significant releases. As the ignition probability for both is around 1 in 50 and there have only been 212 significant oil releases and 307 minor it can be seen that there have simply not been enough instances to generate a statistically valid result for this case.

For gas releases the number of releases is larger and so the difference in ignition probability between minor and significant releases would appear valid.

As the number of major releases is small for all materials, with the largest number being 114 gas releases, no conclusions can be drawn as to whether this effect would continue. The absence of ignited major releases during the present lifetime of the release reporting scheme does not mean the chance of ignition is nil, only that there have not been enough releases for a low probability event to occur.

Broad ignition probabilities for all release sizes are in Table 11.

Table 11 Summary of ignition probabilities for all release sizes

Material	*Ignition probability*
Oil	1 in 48
Gas	1 in 33
2-phase	No ignitions
Condensate	1 in 17
Non-process	1 in 3

The above data shows that non-process releases have by far the highest ignition probability with 1 in 3 releases igniting. The individual fluids released are identified in Table 12.

Table 12 Ignition probabilities for non-process releases

Material	Total number of releases	Number of ignitions	% ignition probability
Diesel	161	37	23.0
Lubricating oil	58	42	72.4
Glycol	16	7	43.8
Hydraulic oil	16	3	18.8
Fuel oil	11	1	9.0
Hellifuel	7	1	14.3
Heat transfer	4	2	50.0
Methanol	2	2	100
Oil-base mud	21	0	0
Seal oil	1	0	0

From Table 12 it is evident that the most prevalent non-process release is diesel, resulting in 37 fires over the survey period: followed by 58 releases with 42 ignitions for lubricating oil.

The majority of fires arising as a result of these releases were in Zone 2 areas. With there being 25 following lube oil releases, and 31 diesel fires.

2.6 EFFECTIVENESS OF GAS DETECTION

Table 13 shows the effectiveness of gas detection systems at detecting releases.

Table 13 Percentage of releases detected by gas detection systems

Material	*Release size*	*Total releases*	*Number detected*	*% detected*
Gas	Major	114	71	62.2
	Significant	932	518	55.6
	Minor	480	264	55.0
	Total	**1526**	**853**	**55.9**
Condensate	Major	1	0	0
	Significant	57	27	47.4
	Minor	148	48	32.4
	Total	**206**	**75**	**36.4**
2-phase	Major	38	4	10.5
	Significant	157	53	52.9
	Minor	31	15	48.4
	Total	**226**	**72**	**31.9**

The above confirms that the provision of gas detection equipment is not an infallible means of detecting a release as ventilation patterns are often complex and the size and complexity of modules often renders it extremely difficult to site detectors. Some 44 % of all gas releases, or 38 % of major gas releases remain undetected by the equipment fitted for that purpose.

Detection rates for condensate or 2-phase releases by gas detection equipment are lower at 36 % and 32 %, respectively. But in part this would be expected as these will have different properties and behaviour compared to a gas release.

3 CONCLUSIONS

Information submitted by the oil and gas industry on OIR/12s provides an extensive information source. A detailed review of this data has been performed to identify materials released, the number of releases, and whether an ignition occurred, among other factors. This information has been used to establish ignition probabilities for releases, from actual reported data, rather than the 'best estimate' values sometimes input into a quantified risk assessment due to lack of data.

In many cases the review has provided reliable information on ignition probabilities. However, there are several instances where the number of reported releases in a particular situation is small. Thus, it has not always been possible to draw a statistically valid conclusion as to a true ignition probability, and values derived may need to be regarded as indicative ignition frequencies, rather than absolute.

The main findings are as follows.

a. In line with expectations ignition probabilities are lower in more highly classified hazard zones: 3 % of Zone 1 releases ignited, 6 % of Zone 2, and 16 % in unclassified areas. Given the rigorous nature of controls, standards of equipment etc. in zoned areas, ignition probabilities in the region of 3 – 6 % for flammable releases would appear extremely high.
b. Analysis of ignitions by material show non-process releases are both the most common cause of fire and have the highest ignition probability: approximately 1 in 3 releases ignite – even in Zone 1 areas. Detailed examination of the HCR data shows 161 fires associated with escape of diesel and 58 due to lubricating oil.
c. Comparison of ignition probabilities for materials according to release size has shown minor releases may be more likely to ignite. For some materials, however, the number of releases are small, so the apparent decrease in ignition probability may be an artefact.
d. The absence of ignited major releases cannot be taken to mean that major releases will not ignite. In line with point (c), above, it simply means there have been insufficient major releases to generate a statistically valid release.

   Given that ignition probabilities are around 1 in 50 for many materials reviewed, and the number of reported major releases for the worst case is only just over 100, it is easy to see there have simply not been enough rolls of the dice.
e. The review of emergency actions shows:
   a. the larger the release to more likely it is that musters will be called or other emergency actions taken; and,
   b. musters or other emergency actions are more likely to be called following ignited releases.

   It has also been found that even with minor releases there have been a number of cases where personnel were mustered, not at stations, but at the lifeboats, demonstrating the perceived severity of the event. Given that the Piper Alpha disaster started with a minor release, such prudence cannot be criticised.
f. Study of figures relating to detection of releases with gas detection equipment has shown some 44 % of all gas releases, or 38 % of major gas releases remain undetected by the equipment fitted for that purpose. This would raise considerable doubts about the placement of such equipment.

4 RECOMMENDATIONS

a. The reporting of hydrocarbon releases should continue, as it is both a useful source of data, and can provide evidence on the effects of implementation of safety measures.
b. The very high instance of fires following non-process releases should be targeted by HSE and industry as a chance of ignition of 1 in 3 is unacceptable.
c. It has been found that a large number of gas releases remain undetected by equipment installed specifically for that purpose. Given this, and the known difficulty in siting such equipment in often complex spaces it is recommended that moves towards the installation of other detection equipment such as acoustic detectors be continued as a secondary means of detection.

APPENDIX A – SEVERITY CLASSIFICATION

Throughout this report the classification scheme for offshore releases has been used which assigns releases to three grades of severity: minor; significant; and major. The following definitions of these have been reproduced from the Offshore Hydrocarbon Releases Statistics and Analysis, 2002, HID Statistics Report, HSR 2002 002.

DEFINITIONS

MAJOR: "Potential to quickly impact outwith the local area, e.g. affect the Temporary Refuge (TR), escape routes, escalate to other areas of the installation, causing serious injury or fatalities".

A major release, if ignite, would be likely to cause a "major accident", i.e. it would be of a size capable of causing multiple casualties or rapid escalation affecting TR, escape routes, etc..

SIGNIFICANT: " Potential to cause serious injury or fatality to personnel within the local area and to escalate within that local areas e.g. by causing structural damage, secondary leaks or damage to systems".

A significant leak, if ignited, might have the potential to cause an event severe enough to be viewed as a "major accident" or be of a size leading to significant escalation within the immediate area or module.

MINOR: "Potential to cause serious injury to personnel in the immediate vicinity, but no potential to escalate or cause multiple fatalities".

A minor leak, if ignited, would not be expected to result in a multiple fatality event or significant escalation, but could cause serious injuries or a fatality local to the leak site or within that module only.

CRITERIA

MAJOR:

(i) Gas Releases:

EITHER	[Quantity released > 300 kg]
OR	[Mass release rate . 1 kg/s AND duration > 5 mins]

This could result in a jet fire over 10 m long (> 1 kg/s) capable of causing significant escalation after 5 minutes duration, or a flash fire/explosion on reaching LFL. Where 300 kg equates to approx. 3000 m^3 explosive cloud at NTP, enough to fill an entire module or deck area, and to cause serious escalation if ignited.

(ii) Liquid Releases (Oil/Condensate/Non-process):

EITHER	[Quantity release > 9000 kg]
OR	[Mass release rate >10 kg/s AND duration >15 minutes]

This could result in a pool fire over 10 m in diameter (>10 kg/s) filling a module or cutting of a deck, hindering escape and affecting more than one person directly if lasting for over 15 minutes duration.

(iii) 2-phase Releases:

EITHER [Quantity of liquids released > 300kg]

OR [Liquids mass release rate >1 kg/s AND duration >5 mins]

Combinations of the major gas and liquids scenarios described above are possible, depending on the gas to oil ratio (GOR) involved.

MINOR:

(i) Gas Releases:

EITHER [Quantity release < 1 kg]

OR [Mass release rate <0.1 kg/s AND duration < 2 mins]

This could result in a jet fire less than 5 m long (<0.1 kg/s) which is unstable (<2 mins duration) and therefore unlikely to cause significant escalation, or a flash fire/explosion on reaching LFL. Where <1 kg equates to <10 m^3 explosive cloud at NTP, probably insufficient to cause a significant hazard if ignited.

(ii) Liquid Releases (Oil/Condensate/Non-process):

EITHER [Quantity released < 60 kg]

OR [Mass release rate <0.2 kg/s AND duration , 5 mins]

This could result in a pool fire smaller than 2 m in diameter (<0.2 kg/s) unlikely to last long enough to hinder escape (<5 mins), but could cause serious injury to persons nearby.

(iii) 2-Phase Releases:

EITHER [Quantity released <1 kg]

OR [Liquids release rate <0.1 kg/s AND duration < 2 mins]

Combinations of the gas and liquids scenarios described above are possible, depending on GOR involved.

SIGNIFICANT: (Those between major and minor)

(i) Gas Releases:

Capable of jet fires 5 to 10 m long lasting for between 2-5 mins, or release rates between 0.1 – 1 kg/s lasting 2/5 mins giving explosive clouds of between 10 to 3000 m^3 in size.

(ii) Liquid Releases (Oil/Condensate/Non-process):

Pool fires between 2 and 10 m in diameter, lasting for between 5 and 15 minutes.

(iii) 2-Phase Releases:

Combinations of the gas and liquids scenarios described above are possible.